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Comparative evaluation of two pediatric rotary file systems in primary teeth: A scanning electron microscope study

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Highlights

- Rotary file systems having instruments of shorter length, variable taper and individual files for anterior and posterior teeth make them suitable for routine use in pulpectomy.
- Kedo-S and Pro AF Baby Gold rotary files were significantly better than manual Ni-Ti K files when the smear layer was evaluated by a scanning electron microscope.
- These new file systems can be used in endodontic practice in primary teeth for faster and better instrumentation.

Abstract

Aim: The objective of this in-vitro study was to evaluate and compare the smear layer formed using Kedo-S, Pro AF Baby Gold rotary files and manual Ni-Ti files in the root canals of primary anterior teeth. **Methods**: Sixty primary maxillary incisors which fulfilled the inclusion criteria were randomly assigned into 3 groups of 20 teeth each; Group 1: Kedo-S rotary files, Group 2: Pro AF Baby Gold rotary files and Group 3: manual Ni-Ti K files. The root canals in each group were instrumented for 3 minutes and irrigated intermittently with 0.9% saline. The teeth were then longitudinally sectioned and examined under a scanning electron microscope for smear layer formation at different thirds of the root canals. Scores obtained were then subjected to statistical analysis. **Results**: Inter-group comparison showed a significant difference between the coronal and middle third in all three groups. A statistically significant difference was also noted in the three groups at the different thirds of the root canals on the intra-group comparison. **Conclusions**: Both Kedo-S and Pro AF Baby Gold rotary files were significantly better than manual Ni-Ti K files in effectively debriding the root canal walls of primary teeth as evaluated by the smear layer.

Keywords: Deciduous Tooth; Pulpectomy; Root Canal Therapy; Smear Layer

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INTRODUCTION

The objective of root canal preparation using the rotary and/or hand instruments is to remove remaining pulp tissue, eliminate microorganisms, remove debris and shape the root canals so that the root canal system can be cleaned and filled.[1,2] The cleaning and shaping procedure creates dentin debris and a smear layer as a consequence of their action on the canal walls.[3] The presence of a smear layer may prevent antimicrobial agents from gaining access to the infected dentinal tubule.[4]

The root canals of anterior primary teeth are relatively simple having a conical shape with few irregularities. Barr et al.[5] were the first to describe the biomechanical preparation of root canals with nickel-titanium ProFile 0.04 rotary files in primary teeth. The use of a rotary system aids in uniform preparation and adequate debridement of root canals, decreased duration of time for root canal preparation and a good taper to the preparation.[5] Considering that rotary files are more convenient to use and can facilitate root canal treatment, their application may be more appropriate to use in children with behaviour management problems.[6,7] Since then the use of various rotary Ni-Ti systems for instrumentation of the primary root canals became popular among pediatric dentists.

Kedo-S files were the first rotary files introduced in 2017 for instrumentation exclusively in the primary root canals.[8] It consists of three Ni-Ti files namely- D1, E1, and U1. The total length of the file is 16 mm with a working length of 12 mm. All these files have a variable taper corresponding to their use in primary teeth. D1 and E1 have a file tip diameter of 0.25 mm and 0.30 mm respectively and are used in primary molars whereas U1 has a file tip diameter of 0.40 mm and is used in primary incisors.[8] Another recently introduced rotary file system for use in primary teeth is the Pro AF Baby Gold files. These files are 17mm in length. It consists of five flexible files namely B0, B1, B2, B3 and B4 made of Ni-Ti Controlled Memory (CM) wire having a constant taper of 4% and 6%.[9]

There are many reports on the cleaning ability of different hand and rotary instruments.[10-14] However, there is paucity in the literature on the comparison of rotary files that are used exclusively for primary teeth. Hence the present scanning electron microscope (SEM) study was undertaken to compare the effectiveness of Kedo-S and Pro AF Baby Gold rotary files with that of manual Ni-Ti K files in root canals of primary anterior teeth.

METHODS

Ethical approval

Approval for the study was obtained from the Institution Ethics Review Committee (Ref. No.:240/2018-19).

Sample

A total of 60 extracted primary maxillary anterior teeth with at least two-thirds root length were selected for this study. Over-retained teeth or teeth indicated for extraction were included in the study. Teeth with internal/external root resorption or root canal calcification were excluded. The teeth were mounted on plaster blocks and then decoronated at the level of the cemento-enamel junction with a diamond disc. They were then randomly assigned to 3 groups of 20 teeth each by a toss of a coin as follows; Group 1: Kedo-S rotary files (Reeganz dental care Pvt Ltd, India), Group 2: Pro-AF Baby Gold (Dentobizz, India) rotary files and Group 3: manual Ni-Ti K files (Dentsply Maillefer, OK, USA).

In Group 1, the initial negotiation of the canals was performed using stainless steel No.15 K hand file followed by instrumentation with Kedo-S U1 rotary file at 300 rpm in crown down manner according to the manufacturer's instructions.

In Group 2, root canals were initially instrumented manually using K hand file size #20. The entire canal was then instrumented with size #30 or #40 file having a 4% taper. The Pro AF Baby Gold rotary files were used in a brushing motion at 250 rpm according to the manufacturer's instructions. In Group 3, root canals were manually instrumented using Ni-Ti K files. The canals were prepared initially with No.10 and No.15 file followed by enlargement to three sizes larger than the initial file.

The root canals of all teeth were instrumented for 3 minutes and intermittently irrigated with 0.9% saline during preparation and finally dried with absorbent paper points. Following root canal preparation, two longitudinal grooves, not deep enough to enter the canals were prepared on the palatal and facial surfaces of each root with a diamond disc under a high speed to facilitate vertical splitting into two halves. A plastic instrument was then used to separate the cut halves and the section with the most visible part of the apex was conserved, processed and gold-sputtered for examining under Scanning Electron Microscope (SEM) at 1000x magnification.

Evaluation of smear layer was done according to scores given by Hulsmann et al.[15] (Table 1). Individual scores for each third of the root canal in all 3 groups were recorded.

Data obtained was subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp. The intra-group and inter-group comparison of smear layer scores between different thirds of the root canals were done using Friedman's test and Kruskal Wallis test respectively. The level of significance was set at $p < 0.05$.

RESULTS

A significant difference in mean scores for the smear layer was observed between different thirds of the canals in each group ($p < 0.05$). In comparison to the coronal and middle thirds, the smear layer was found to be higher in the apical third of the root canals (Table 2). The inter-group comparison showed a significant difference in mean scores for smear layer in only the coronal ($p=0.03$) and middle thirds ($p=0.01$) of the canals (Table 3).

Table 1. Scoring criteria for smear layer

Score 1	No smear layer, dentinal tubules open
Score 2	Small amount of smear layer, some dentinal tubules open
Score 3	Homogenous smear layer covering the root canal wall, only few dentinal tubules open
Score 4	Complete root canal wall covered by homogenous smear layer, no open dentinal tubules
Score 5	Heavy, inhomogenous smear layer covering the complete root canal wall

Table 2. Intra-group comparison of smear layer values

Groups	Thirds	Smear Layer Values (Mean ± SD)	p value
Group 1	Coronal	3.45 ± 0.69	
	Middle	2.75 ± 0.79	0.001*
	Apical	3.80 ± 0.62	
Group 2	Coronal	3.35 ± 0.75	
	Middle	3.55 ± 0.69	0.04*
	Apical	3.80 ± 0.70	
Group 3	Coronal	2.70 ± 1.03	
	Middle	3.05 ± 1.00	0.002*
	Apical	3.50 ± 0.51	

*p < 0.05 is significant

Table 3. Inter-group comparison of smear layer values between different thirds

Root Canal	Thirds	Smear Layer Values (Mean ± SD)	p value
Coronal	1	3.45 ± 0.69	
	2	3.35 ± 0.75	0.003*
	3	2.70 ± 1.03	
Middle	1	2.75 ± 0.79	
	2	3.55 ± 0.69	0.01*
	3	3.05 ± 1.00	
Apical	1	3.80 ± 0.62	
	2	3.80 ± 0.70	0.25
	3	3.50 ± 0.51	

*p < 0.05 is significant

Representative SEM image showed a thick homogeneous smear layer at the apical third of the root canals in Group 1 and Group 2, respectively (Figures 1C and 2C). In Group 2, very few open dentinal tubules were visible at the middle third (Figure 2B). In comparison to the other groups, smear layer in all thirds of the canal was observed to be less in Group 3 (Figure 3).

DISCUSSION

Chemo-mechanical preparation is an integral part of root canal treatment. It includes mechanical cleansing with instruments and irrigants to remove infected tissues and residual necrotic material, providing the ideal conditions for healing and integrity of the radicular structure.[16] Cleaning efficiency depends on many factors including the type of instrument, instrumentation technique and irrigating solution in addition to the inherent anatomy of the root canal system.[17]

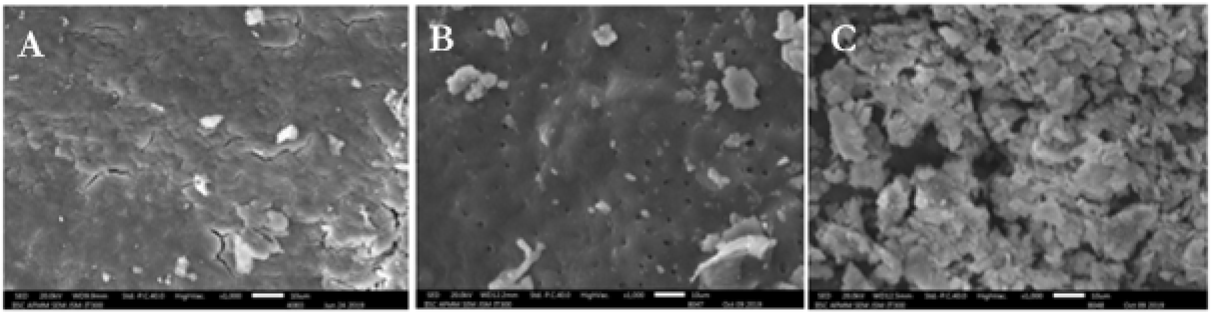

Figure 1. Representative SEM images showing smear layer following instrumentation with Kedo-S rotary files. A: Coronal third; B: Middle third; C: Apical third

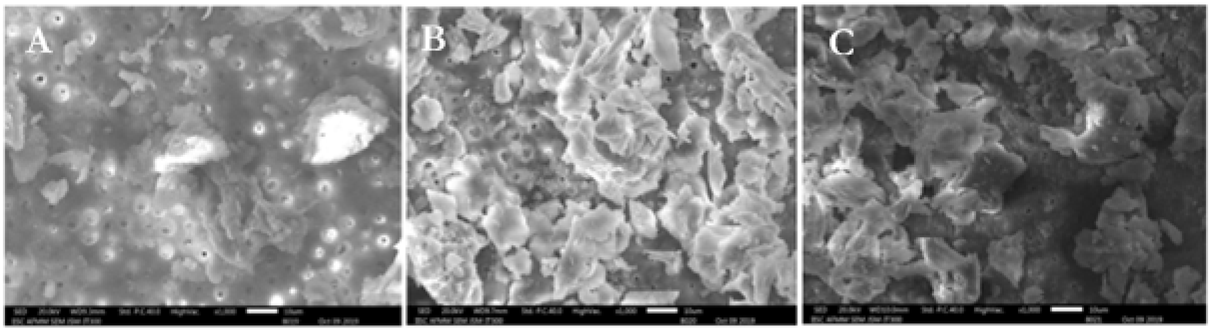

Figure 2. Representative SEM images showing smear layer following instrumentation with Pro AF Baby Gold rotary file. A: Coronal third; B: Middle third; C: Apical third

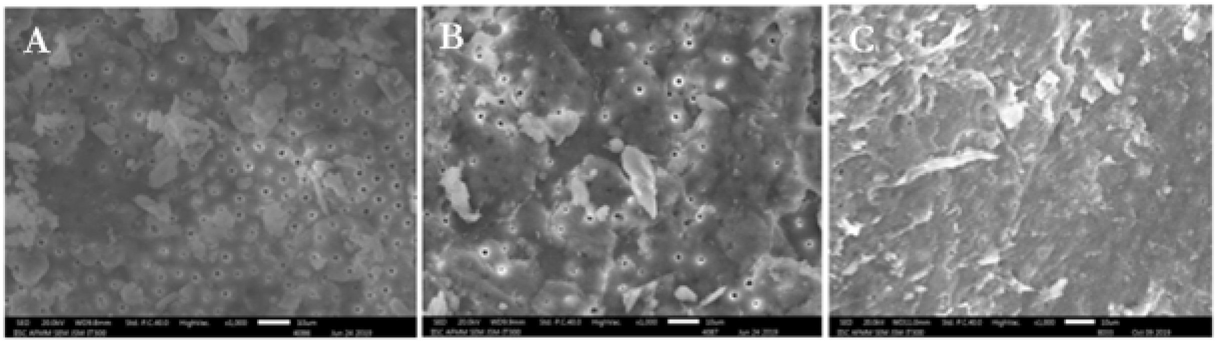

Figure 3. Representative SEM images showing smear layer following instrumentation with Ni-Ti manual files. A: Coronal third; B: Middle third; C: Apical third

In the field of pediatric endodontics, manual Ni-Ti files are routinely used. Although the use of rotary files in primary teeth was introduced in 2001[5], their application has been limited due to factors like operator's skill, knowledge of rotary systems, and root canal anatomy of primary teeth. Practitioners have felt the need for a change in length, design and configuration of the existing rotary files for convenient use in young children. Recently two new rotary file systems; Kedo-S files and Pro AF Baby Gold files, have been introduced for exclusive use in primary teeth. Although there are clinical studies evaluating the efficiency of Kedo-S rotary files[18,19], there are no published reports on the use of Pro AF Baby Gold rotary files. Therefore, the present study was undertaken to evaluate the cleaning efficiency of these two newly introduced files using a Scanning Electron Microscope (SEM).

According to the American Association of Endodontists, a smear layer is a surface film of debris retained on dentin after instrumentation with either rotary instruments or manual files; consists of dentin particles, remnants of vital or necrotic pulp tissue, bacterial components and retained irrigant.[1] It is composed of organic and inorganic contents including hard tissue remnants, coagulation proteins, necrotic pulp tissue residues, various blood cells, and micro-organisms that infect dentin tubules.[2]

In the present study, primary maxillary incisors with a root length of 7-8 mm were selected in order to evaluate the smear layer along the entire length of the canal. Since normal saline is known not to alter the smear layer[20-22], it was used as an irrigant during instrumentation of the root canals. The smear layer was evaluated at coronal, middle and apical thirds of the canals under a scanning electron microscope (SEM). High magnification (1000x) photomicrographs enabled the evaluators to appreciate the smear layer and dentinal tubules. Scoring of the smear layer was done using the criteria given by Hulsmann et al.[15], which is a gold standard.

In accordance with previous reports[23-25], a greater amount of smear layer was produced with both rotary file systems in comparison with manual files. There are conflicting views on the role of the smear layer. The presence of a smear layer may prevent penetration of medicaments and filling materials into the dentinal tubules, or even contacting the canal walls. Conversely, the smear layer can plug the orifices of dentinal tubules, to form a protective diffusion barrier against bacterial penetration.[26] With the rotary files, a homogeneous smear layer with few open dentinal tubules was observed at the coronal third. Unlike the manual Ni-Ti files, these files have a great taper and tend to bind against the coronal wall resulting in significant dentin removal. Moreover, Kedo-S files brought about coronal flaring of the root canals. Clinically, this could be an advantage as it facilitates the insertion of filling materials during obturation. In comparison to both manual and Pro-AF Baby gold rotary files, significantly less smear layer at the middle third was observed with Kedo-S rotary files. The binding of U1 file (Kedo-S) in the coronal third probably resulted in under-instrumentation of the middle third of the root canal. With the Pro-AF Baby Gold rotary files a greater amount of smear layer was formed as it is required to instrument the canals using two files sequentially, according to the manufacturer's instructions. Also, unlike Kedo-S files which have a variably variable taper, Pro AF Baby Gold files are thinner and more flexible with a 4% taper. The presence of a smear layer at the apical portion of the root canal can harbour microorganisms and is considered the main cause of endodontic failure.[27] In the present study, a considerable amount of smear layer was formed at the apical third with both manual and rotary files. This further emphasizes the need for copious irrigation during instrumentation.

In the present study, manual instrumentation with Ni-Ti files showed a lesser smear layer on the walls of the root canals. Due to their flute design and aggressive cutting, both the rotary file systems effectively debrided the root canal walls which caused more smear layer formation.

This in-vitro study was limited to the use of rotary file systems in primary maxillary incisors. However, these files require cautious use under controlled speed particularly in narrow and resorbing root canals of primary teeth.

Rotary file systems having instruments of shorter length, variable taper and individual files for anterior and posterior teeth make them suitable for routine use in root canal preparation of primary teeth. It can provide the clinician ease of operation as compared to manual files. Paediatric rotary files can thus be used in routine endodontic practice in primary teeth for faster and better instrumentation.

CONCLUSIONS

It was concluded that the overall performance of both Kedo-S and Pro AF Baby Gold files were superior in terms of cleaning efficacy when compared with that of manual Ni-Ti K files.

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Declarations

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